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Microclimate and human comfort considerations in planning a historic urban quarter

Amany A. Ragheb [a,*], Ingy I. El-Darwish [b], Sherif Ahmed [c]

[a] *Faculty of Engineering, Delta University for Science and Technology, Mansoura, Egypt*
[b] *Faculty of Engineering, Tanta University, Tanta, Egypt*
[c] *High Institute of Engineering and Technology, Beheira, Egypt*

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Abstract

Lately, unexpectedly developing urban regions have been observed worldwide. This boom has an instantaneous impact on the microclimate and for this reason on human comfort, as a result negatively affecting international climate and power consumption degrees. Urban design selections together with road geometry and orientation, sidewalk widths, shading structures, materials, landscaping, building heights and air drift are key elements for pedestrian thermal comfort. This evaluation covers the built environment's moderation components impact at the weather, with the purpose for optimizing the thermal comfort degree in out of doors urban area. The literature covers using simulation equipment to be expecting out of doors environmental situations with specific knowledge on Envi-met as a simulation device for comparing outside thermal comfort. Sooner or later, the paper expects to spotlight the microclimatic enhancement approaches, and the usage of simulation as a device in the field of urban layout.

The paper focuses on the importance of air temperature, relative humidity, air motion, and suggests radiant temperature in city canyons in addition to in open public spaces for the sake of human thermal comfort. As at the micro-scale, an old historical district south Kom Al Shoqafah by Al Mahmoudiyah Canal in Alexandria has been studied. The consequences deliver some initial proof of the wonderful urban microclimate with the aid of the use of simulation strategies that may influence the city area design and the planning procedure. This study proved that the microclimatic conditions in a critical historic region are in a near relationship among human consolation and urban design. The study is for evaluating the opportunity of changing the microclimate through distinct design parameters that have strongly impact the microclimate.

Keywords: Urban microclimate; Human comfort; Urban design; Outdoor urban spaces environment; Simulation

1. Introduction

The lifestyles for thousands of people dwelling in towns may be advanced through improving the elements that have an effect on the urban microclimate, and the form of the city responds to them in the correct way to its site. The issue isn't always to supply an excellent plan derived from climatic concerns, but as a substitute to provide a practicable plan for pedestrian comfort on the outdoor space. Mills (2006) referred to that "while the meteorologically ideal settlement serves a useful pedagogical purpose,

* Corresponding author.
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it does not recognize planning realities where climate issues are rarely a dominant concern". According to Brown, the outdoor environment, especially in hot arid countries (including Egypt), tends to be poorly regulated and not thermal comfortable.

The microclimate of urban open areas is motivated by numerous parameters, which includes urban form and geometry, urban density, vegetation, water levels and the properties of surfaces (Balafoutis et al., 1998; Setaih et al., 2013). Climatic and physical factors are combined in order to achieve sustainable human thermal comfort conditions (Ragheb et al., 2015a,b).

This paper demonstrates modern plans sprawl situations on an urban area of the old district at by means of Al Mahmoudiyah Canal in Alexandria city. Al Mahmoudiyah Canal has been a focal matter for all Alexandria's governorate plans for the beyond forty years. There has not been a plan thinking about microclimatic situations which has direct effect on human comfort. The studies compare Kom Al Shoqafah district present scenario to a predicted urban design of the same region, thinking about microclimatic conditions as well as evaluating it to proposed designs. A simulation has been used to assist make choices about legislative measures that could positively improve human thermal comfort.

The particular aim of the study is to improve the outdoor thermal conditions with the aid of the design having sufficient open spaces, proper paving, vegetation and water levels; by means of comparing current, probable and proposed urban designs to adjust current legislative planning and constructing measures. The paper's intention is to enhance the understanding of outdoor human factors and microclimatic issues to be able to preserve and maintain well designed ancient areas in collaboration with adaptive reuse with conservation measures.

1.1. .Urban microclimate

Climate is the long term behavior of the surroundings in a selected region, with specific features such as, temperature, pressure, wind, precipitation, cloud cowl and humidity. An urban area is an area with a high density of human created structures in comparison with the regions surrounding it (Mahgoub et al., 2013; El-Shimy et al., 2015). A microclimate is a local atmospheric region where the climate differs from the encircling area. The term may refer to areas as small as a few square meters or as large as many square kilometers (Erell et al., 2011). Microclimates exist, as an example, close bodies of water which may cool the local atmosphere, or in heavily urban regions where brick, concrete, and asphalt absorb the solar energy, heat up, and reradiate that warmness to the ambient air; the resulting urban heat island is a type of microclimate.

As it is well defined in the practice-oriented literature urban microclimate relies upon the type of city in terms of size, geographical location, population size and density, and land use in addition to the street design features along with height of buildings, street widths and orientation, subdivision of the building masses, etc. Consequently; the urban design of each neighborhood in a city creates its own unique local climate (Mahgoub et al., 2013).

1.2. Urban design

Urban design is the procedure of designing and shaping cities, towns and villages. Whereas architecture focuses on individual buildings, urban design with the larger scale of groups buildings, streets and public areas, whole neighborhoods and districts, and entire towns, with the intention to make city areas functional, appealing, and sustainable (Parsons, 2013).

The primary target is not to provide an idealized plan derived from climatic concerns, but as an alternative to provide a manageable plan; this is economically viable and accepts that the planner must consider other factors, together with the necessities of transportation systems. Mills (2006) noted that "while the meteorologically ideal settlement serves a beneficial pedagogical purpose, it does not recognize planning realities wherein climate issues are hardly a dominant situation".

Urban design addresses the larger scale of groups of buildings, streets, public spaces, neighborhoods, districts, and entire cities. It is the proactive urban areas design which focuses on the design, quality, character and appearance of places, including buildings and the spaces among them. Urban design is concerned with the subsequent aspects (Erell et al., 2011):

- Pedestrian zones – areas of a city or town reserved for pedestrian-single use and in which some or all automobile traffic may be prohibited.
- Incorporation of nature within a town – preserves and complements the livability of towns, large and small, by incorporating extra nature.
- Aesthetics – creation and appreciation of beauty.
- Urban structure – how a place is put together and how its components relate to each other.
- Urban typology, density and sustainability – spatial kinds and morphologies associated with intensity of use, consumption of resources and manufacturing and renovation of viable communities.
- Accessibility – providing for ease, safety and choice while transferring to and through places.
- Legibility and way finding – helping people to discover their way around and recognize how a place works.
- Animation – designing places to stimulate public activity.
- Function and fit – shaping places to assist their various planned uses.
- Complementary mixed uses – locating activities to permit constructive interaction between them.
- Character and meaning – recognizing and valuing the variations among one location and other.

- Order and incident – balancing consistency and variety in the urban environment in the interests of appreciating both.
- Continuity and change – locating people in time and place, including heritage respect and support for modern culture.
- Civil society – making places in which people are free to encounter each other as civic.

Currently, urban design process is pushed via marketing forces that respond to housing demands. The use of computerized predictive equipment that produces quantitative outcomes for the effect of proposed designs upon climate is a critical degree in facing decision makers that downgrade the significance of climatic attention in urban design. Authorities need to keep in mind these quantitative measures that allow individual buildings to make better use of 'natural energy' and enhances the capability for pedestrian comfort and activities in outdoors areas (Moriwaki and Kanda, 2004; Erell et al., 2010; Ragheb et al., 2013). To define such measures, urban planners should need accurate data concerning the micro climate situation in their towns.

2. Microclimatic considerations in urban design

The combination of climate in planning and design techniques is probably improved if the benefits to be reaped from attaining the goals of the design ought to be large. Their evaluation has to concern on complex and realistic scenarios, if important using automated predictive tools (Erell, 2008). In the absence of quantitative studies on the effect of proposed designs upon climate, and on the basis of well-documented evidence from different planning professions, decision makers generally tend to downgrade the importance of climatic considerations in urban planning. The integration of climate analysis in the design technique must be at early stages, before viable avenues are blocked off by uninformed decisions. Suitable climatic strategies can rarely be applied retroactively to lodging mistakes made in the initial sates of the design. In order to follow urban climatology efficaciously in the process of town planning, a comprehensive technique need to be adopted, balancing various concerns inclusive of pedestrian comfort and building energy savings (Erell, 2008).

The fulfillment of a project is often evaluated by its quick-term economic return to the developers, so climatologists should be able to collaborate with different design group contributors to evaluate the economic effects in their decision recommendations, which includes avenue width or building height, which may also have significant economic implications. However, any evaluation of long-term sustainability ought to also take into account environmental impacts.

2.1. Microclimatic enhancement methods for thermal comfort

There are several urban microclimate moderation processes. Parameters including air temperature mean radiant temperature, relative humidity, and wind speed may be modified by the impact of urban interventions, which hence might enhance the outdoor thermal comfort situations.

2.2. Cool reflective materials

The use of excessive reflective material having the potential to reflect incoming solar radiation in urban environments is a powerful technique to reduce the effects of the thermal environment on pedestrian comfort (Setaih et al., 2013). High albedo materials which had white and light

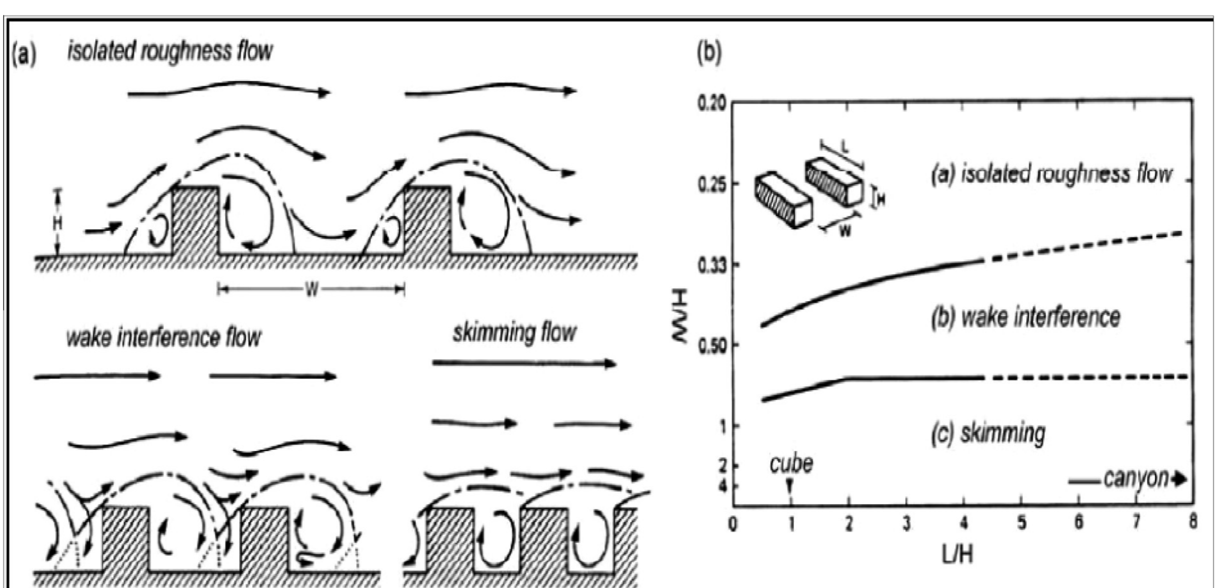


Figure 1. Airflow regimes over an array of barriers (Shishegar, 2013).

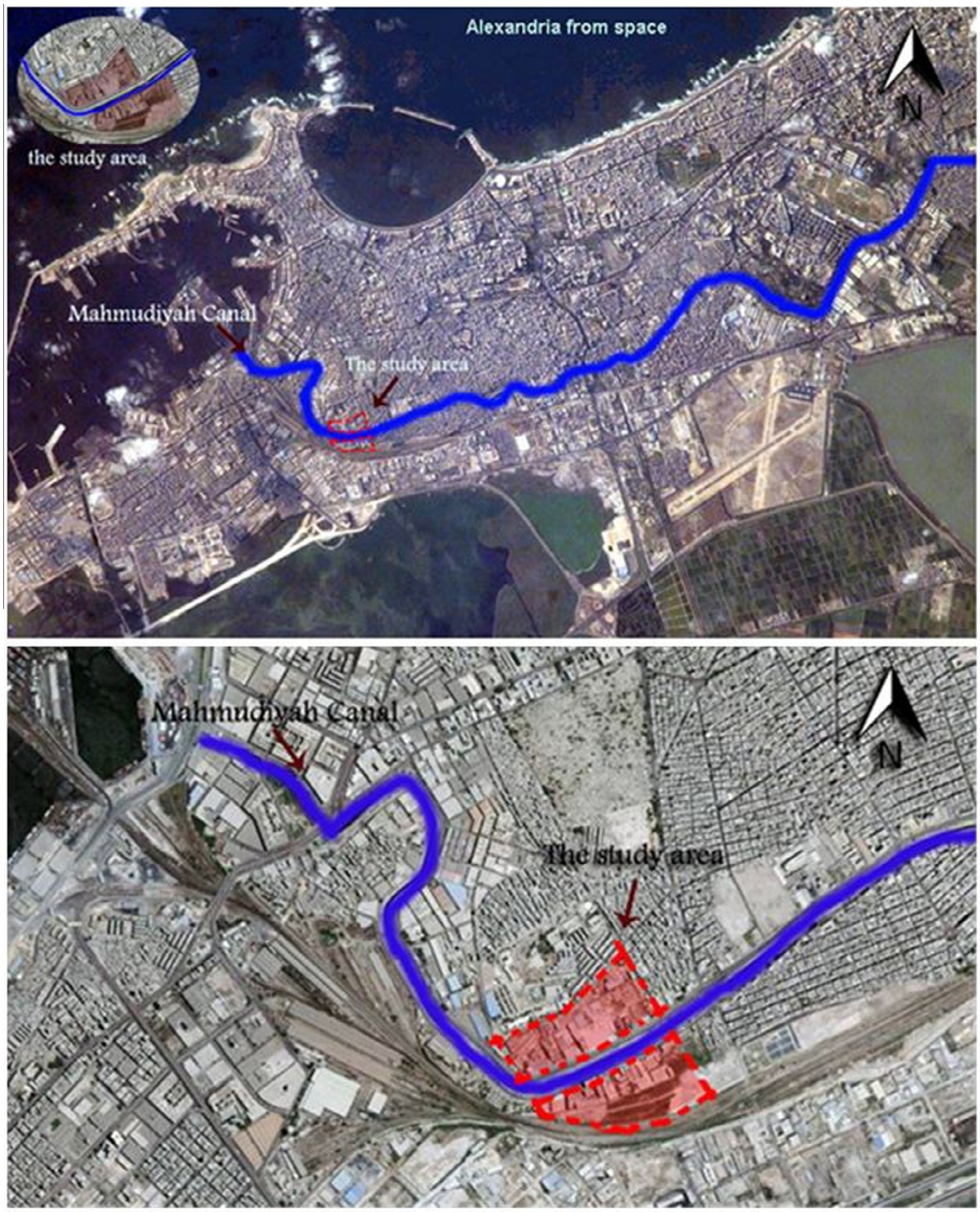


Figure 2. Case study: historical zone of Kom Al Shoqafah by Al Mahmoudiyah Canal west of Alexandria.

colored surfaces were found to have a significant improvement effect on thermal comfort.

2.3. Water surfaces

Water features have usually improved the pedestrian thermal comfort level through decreasing air temperature in warm city built environments. Researchers in japan have examined this concept through altering the temperature in both hot and humid city spaces and confirmed usefulness of water facilities.

2.4. Green spaces and vegetation

One of the great advantages of planting and tree cover is the cooling effect on the consequences from the joint impact of evapotranspiration and canopy shading (Setaih et al., 2013). Vegetation is a common and effective method to enhance the outdoor pedestrian thermal comfort condition. Increasing green spaces in urban regions represents a considerable mitigation method in heat stress relaxation.

2.5. Building arrangements with wind movement

Better design of urban material with air movement can reduce the effect of thermal environment (Fig. 1), as this may control the wind direction and velocity. Wind induced pressure distributions depend on many factors in urban environments. Constructing height, technique-flow, wind direction, urban geometry of buildings and their surroundings are factors which could induce wind speed.

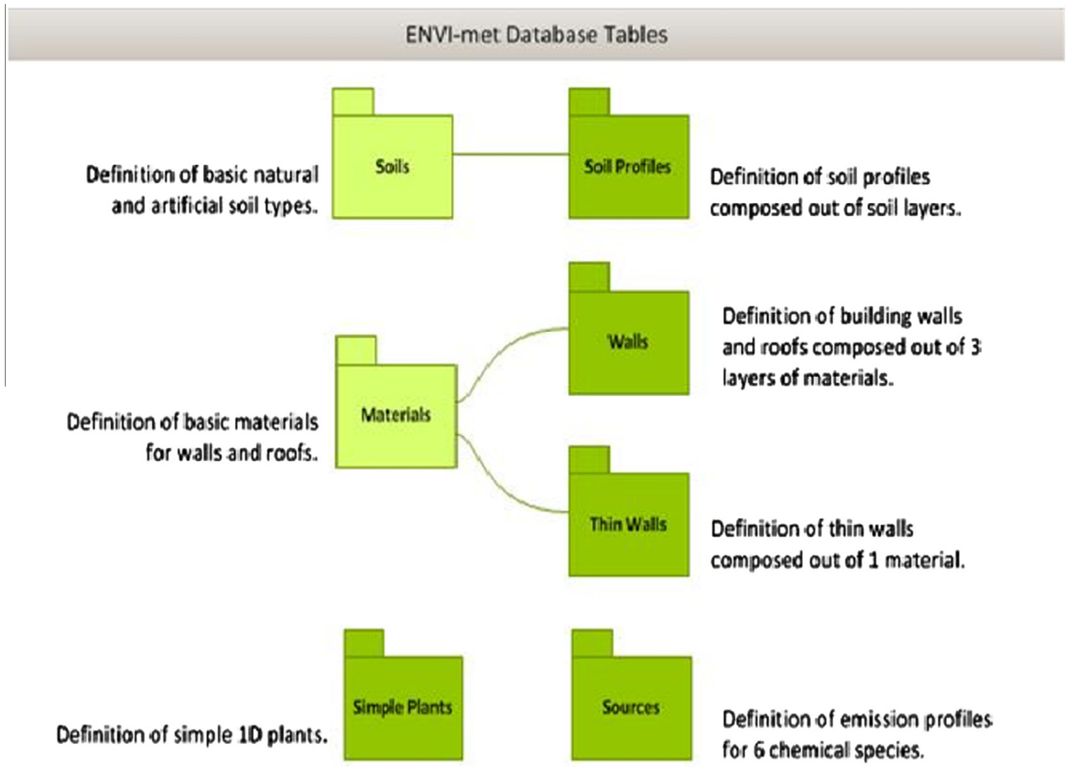


Figure 3. ENVI-met Database. ENVI-met Online Reference.

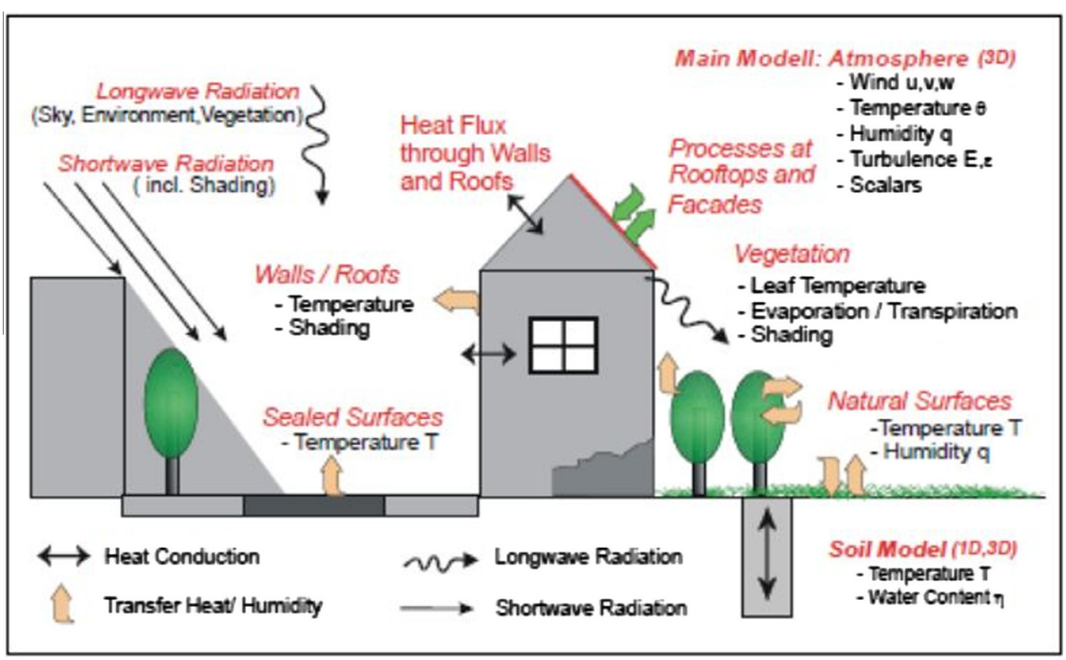


Figure 4. Overview of the different modules in ENVI-met (Jean et al., 2012).

3. Site description

In order to study the local microclimate (air temperature, mean radiant temperature, air speed and humidity) in Alexandria, Egypt, simulation was run on the ancient area of Kom Al Shoqafah through Al Mahmoudiyah Canal west of Alexandria as a proposed study area (Fig. 2). Simulation had run three times concurrently. Readings of the microclimatic parameters had been run consecutively currently, predicted and proposed then compared on each indicator.

Figure 5. The situation of the urban design of the study area.

Table 1
Description of Site design values for the reference sites along the study area.

Site	Proposed design-1	Proposed design-2
Location	29°53′48.54″ East/31°10′43.72″ North 29°53′30.18″ West/31°10′28.01″ South	29°53′48.54″ East/31°10′43.72” North 29°53′30.18″ West/31°10′28.01″ South
Climate region	Hot arid Alexandria is classified under hot arid climate with high humidity at few days around the year	Hot arid
Building types	Industrial/educational/residential	Residential
Total area	Area = 134214.8080, perimeter = 1649.5269	Area = 134214.8080, perimeter = 1649.5269
Buildings footprint	55%	60%
Ground cover (%)	35%	15%
Greens (%)	10%	25%
Water surfaces (%)	(10%)	10%
Goal	Pedestrian comfort in outdoor space	Pedestrian comfort in outdoor space

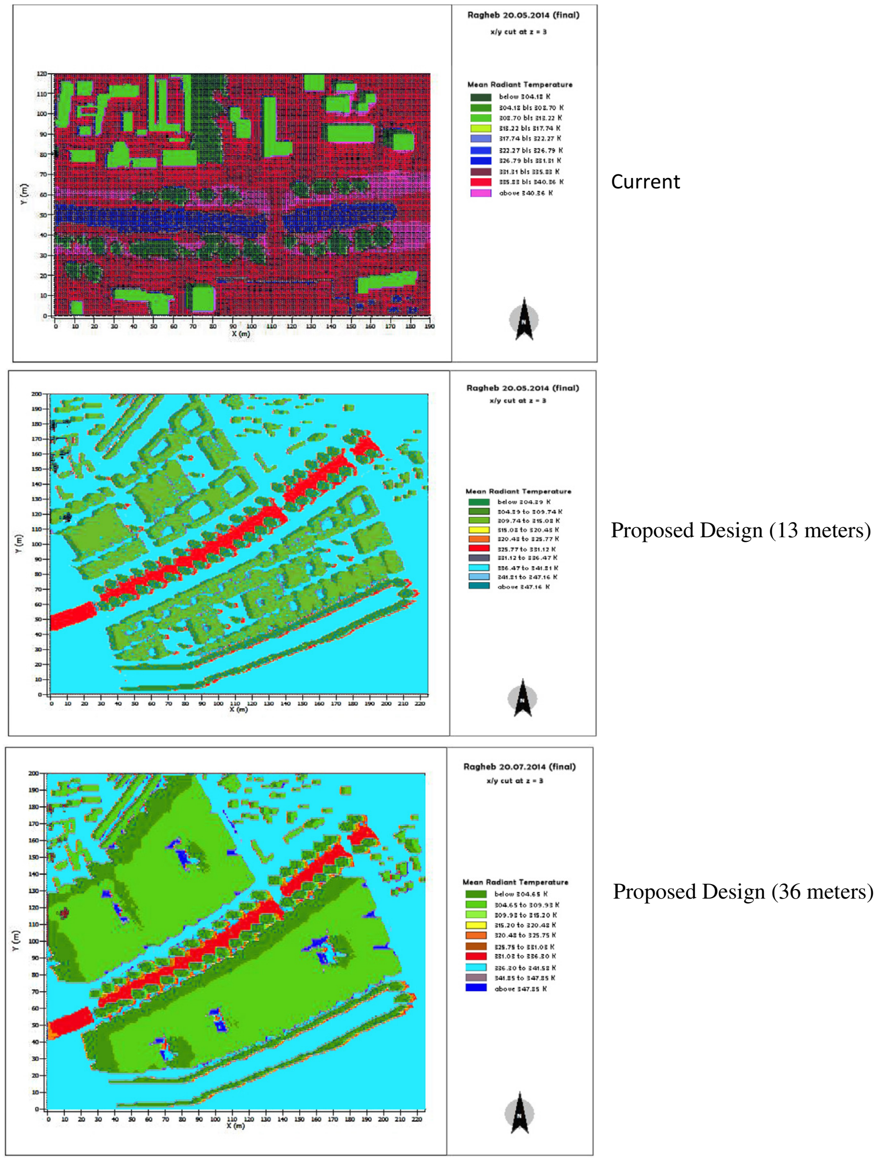


Figure 6. The distribution of the mean radiant temperature MRT along the study area.

Alexandria is the second largest city in Egypt and the second largest metropolitan area after Cairo in terms of size and populace. It has the largest Egypt's harbor, extending about 32 km along the North Western coast of the Mediterranean. It is also considered as the biggest town located directly on the Mediterranean. In addition to its strategic location, Al-Mahmoudiyah Canal passes via southern Alexandria city connecting the river Nile to the Mediterranean Sea. The study area is to the south of an important monumental historic area where the old city of Alexandria existed (Fig. 2). Currently, old factories exist inside the area because of their close location by the canal, railway and harbor. Although few of them are operating because of demolition of the nonfunctioning to the old transportation routes instead. Slums are observed on the north and economic housing on the east sides. Old public buildings which include schools and hospitals are still functioning within the study area.

4. Materials and methods

The microclimate at Street Level was turned into simulation; Envi-met 3.0 was selected as a simulation tool because of its reliable outcomes that was examined via previous researchers (Bruse and Team, 2012). This system uses a three dimensional computational fluid dynamics and energy balance model (Bruse, 2009). The model has a high spatial and temporal decision allowing a detailed observation of the way that microclimate varies inside the studied area over time. The model gives a large quantity of output information together with the essential variables to enable the calculation of thermal comfort indices. A simulation observation study as this one has the benefit that an unlimited number of factors from the model can be analyzed, while in a measurement study, only the consequences derived from the measured spots are dependable (Rosheidat et al., 2008).

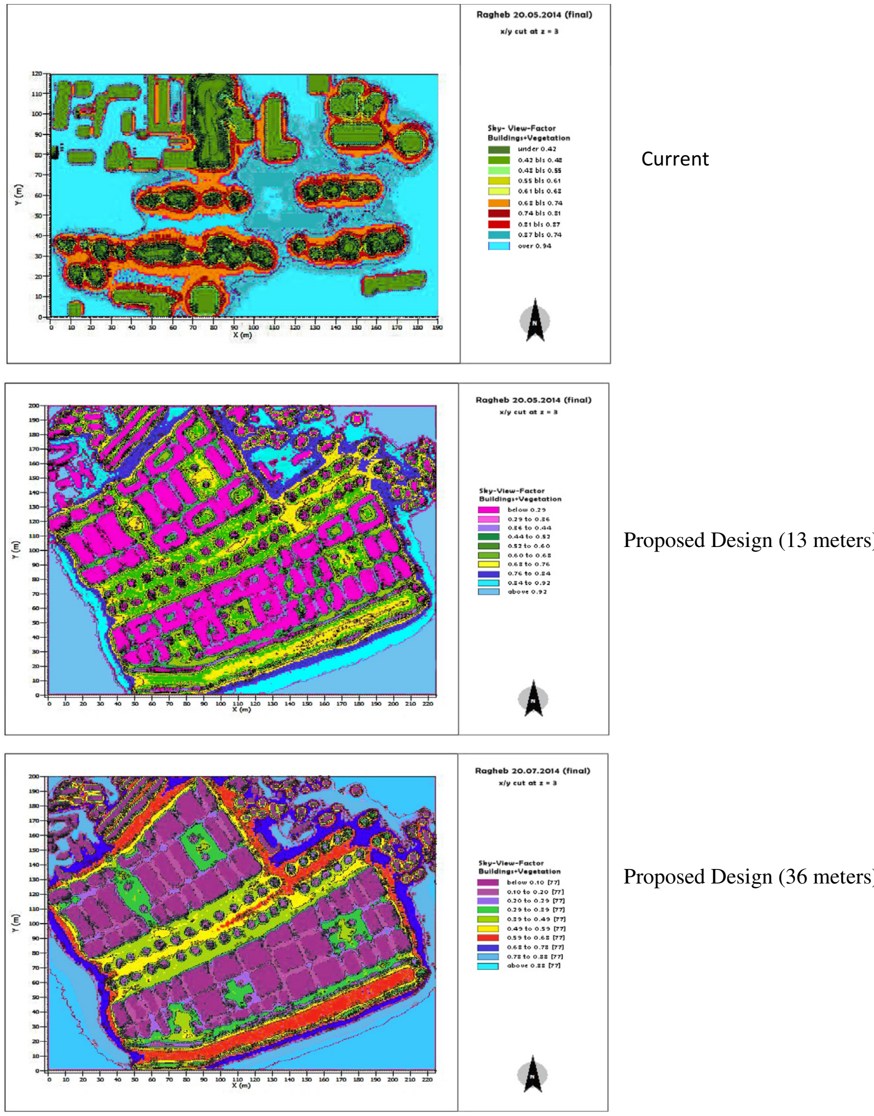


Figure 7. The distribution of the relative humidity RH along the study area.

ENVI-met uses two levels of databases, the System Database and the User/Project Database (ENVI-met Online Reference). The two levels and the databases are similar in their structure and format, however only the User/Project Database can be edited via the user. The User/Project Database has a higher priority than the System Database. In different phrases: if some soil type item a1 is defined as a soil type both in the System Database and the User/Project Database, the information from the User/Project Database will "win" and overwrite the settings from the System Database (Fig. 3).

ENVI-met is unique in the experience that it couples the atmospheric fluid dynamics version to a variety of different models such as a soil model, a radiation model and a vegetation model. An overview of all of the modules carried out in ENVI-met is shown in Fig. 4 (Jean et al., 2012).

Thermal comfort environmental indicators (mean radiant temperature, surface temperature, relative humidity and wind pace) were selected for the study due their strong effect on human beings and alternatively microclimate.

The meteorological input data for the simulation model are dependable computational sources. It carries the physical properties of the studied urban areas (buildings, waterways, soil and vegetation) and limited geographical. For the simulation, the 21 of June at 9.00 AM is chosen due to the fact that in this situation a small change in temperature has strong effects for the thermal comfort. It's a sunny day in summer without cloud coverage and air temperature of up to 30 °C in 2 m above ground and wind speed in 13 m above ground varying from 1 to 3.5 m/s.

5. Results of the *Site Modeling*

The model of the paper is to evaluate current, proposed design-1 (13 m height) including interfere factors to enhance human thermal comfort in addition to microclimate

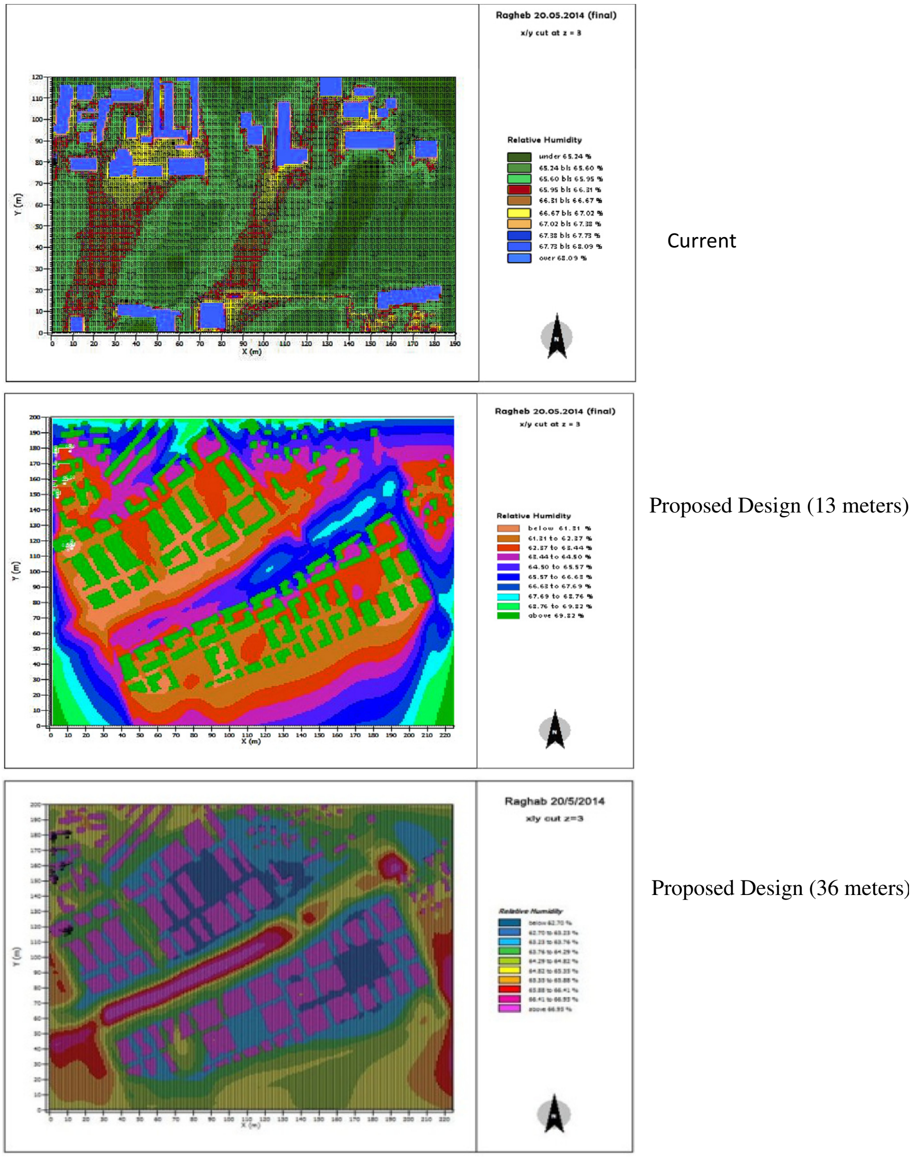


Figure 8. The distribution of the relative humidity RH along the study area.

and a proposed design-2 (36 m height) that applies current guidelines of the proposed design (Fig. 5) (Table. 1).

The output results from the simulation model are representing in four selected area open space (A), Secondary Street Level (B), Street Level (C) and Pavement Level (D), Figs. 6–10. For open space the mean radiant temperature of the current condition is increased from 2 k (2 °C) to 6 k (6 °C) for the proposed designs 1 and 2, respectively, while the surface temperature of the current condition is the same for the proposed design 1 and decrease to 2.3 k (2.3 °C) for the proposed design 2. The relative humidity is decreased 2.5% from the current condition in the proposed design 1 and 0.3% in the proposed design 2. The wind speed increases from the current situation about 0.9 ml sec to 1.89 m/s in the proposed designs 1 and 2 respectively.

Secondary Street Level (B), the mean radiant temperature of the current condition is increased by 1 k (1 °C) at the proposed designs 1 and decreased by 20 k (20 °C) at the proposed designs 2, while, the surface temperature of the current condition is increased by 4.48 k (4.48 °C) for the proposed design 1 and increased by 0.18 k (0.18 °C) for the proposed design 2. The relative humidity is decreased by 5.3% from the current condition in the proposed design 1 and 3.7% in the proposed design 2. The wind speed decreases from the current situation about 0.9 ml sec in both proposed designs 1 and 2.

Street Level (C), the mean radiant temperature of the current condition is increased about 3 k (3 °C) and 2 k (2 °C) for the proposed designs 1 and 2, respectively, while the surface temperature of the current condition increases about 3 k (3 °C) for the proposed design 1 and decrease

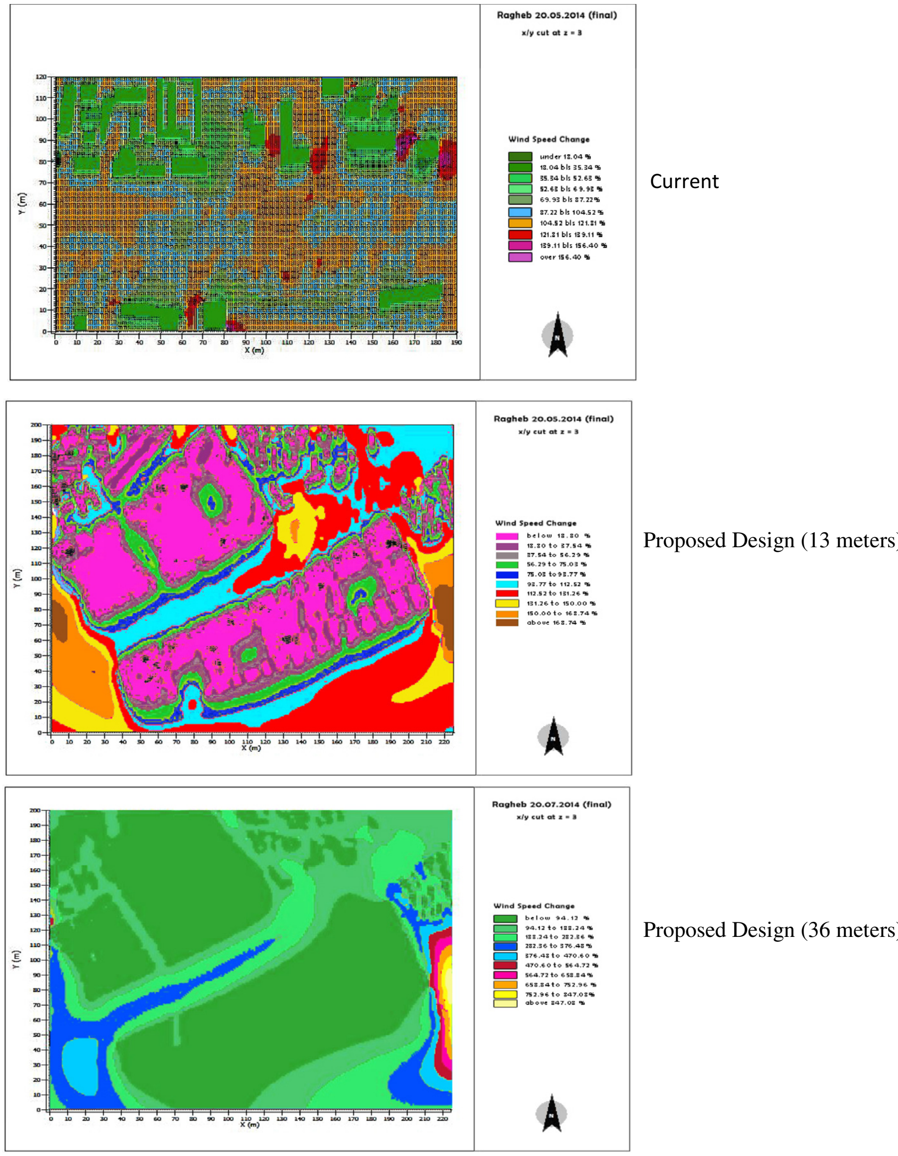


Figure 9. The distribution of the wind speed along the study area.

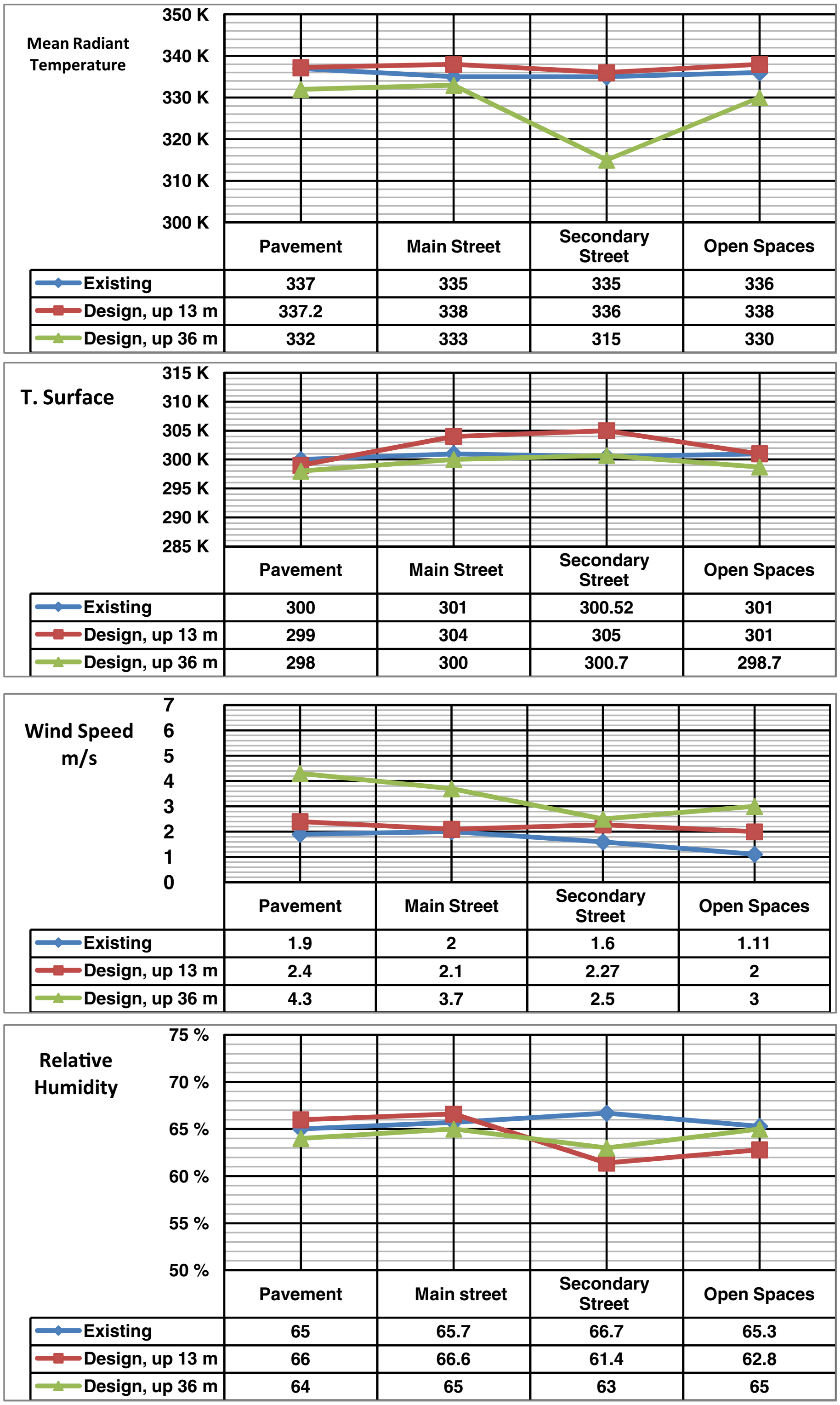
to 1 k (1 °C) for the proposed design 2. The relative humidity is increased by 0.9 % from the current condition in the proposed design 1 and decreased by 0.7 % in the proposed design 2. The wind speed increases from the current situation about 0.1 ml sec to 1.7 m/s in the proposed designs 1 and 2 respectively.

Pavement Level (D), the mean radiant temperature of the current condition is increased about 0.2 k (0.2 °C) for the proposed designs 1 and decreased about 5 k (5 °C) for the proposed design 2, while the surface temperature of the current condition is decreased by 1 k (1 °C)–2 k (2 °C) for the proposed designs 1 and 2, respectively. The relative humidity is decreased by 1% from the current condition in the proposed designs 1 and 2. The wind speed increases from the current situation about 0.5 ml sec to 2.4 m/s in the proposed designs 1 and 2 respectively.

6. Discussion and conclusion

The study indicates that improving microclimate by providing 13 m height buildings with open areas improved wind speed, however did not differ in surface temperature or inside the average radiant temperature. Providing vegetation had an advantageous impact except for the average radiant temperature. Relative humidity had also a positive impact except at Street Level due to the pattern carried out was near the water body. Same design with 36 m building heights had better microclimatic consequences except for the surface temperature on the Secondary Street Level.

This study proved that the microclimatic situations in an essential ancient area are examining the near relationship between human comfort and urban design. It became a try to study the opportunity of converting the microclimate



Mean Radiant Temperature	Pavement	Main Street	Secondary Street	Open Spaces
Existing	337	335	335	336
Design, up 13 m	337.2	338	336	338
Design, up 36 m	332	333	315	330

T. Surface	Pavement	Main Street	Secondary Street	Open Spaces
Existing	300	301	300.52	301
Design, up 13 m	299	304	305	301
Design, up 36 m	298	300	300.7	298.7

Wind Speed m/s	Pavement	Main Street	Secondary Street	Open Spaces
Existing	1.9	2	1.6	1.11
Design, up 13 m	2.4	2.1	2.27	2
Design, up 36 m	4.3	3.7	2.5	3

Relative Humidity	Pavement	Main street	Secondary Street	Open Spaces
Existing	65	65.7	66.7	65.3
Design, up 13 m	66	66.6	61.4	62.8
Design, up 36 m	64	65	63	65

Figure 10. Comparing proposed designs 1 and 2 (10 and 36 m height) to current conditions results.

via extraordinary design parameters that had strong effect on microclimate. The contents have covered microclimatic enhancement techniques which have strong impact on thermal comfort through simulation steps. From the outcomes, it may be visible that it isn't essential to have shorter buildings to provide better microclimate however presenting suitable designs with open spaces and vegetation that undergoes simulation was very essential for pedestrian comfort. Higher buildings can provide more shade subsequently less temperature and higher wind speed and as a result extra comfortable for pedestrians. Higher buildings should fit legislation measures which restricts exceeding

36 m in Egypt, exceeding 36 m can result in indoor human discomfort.

Moreover, this study has addressed a limited scope within the quest of possible utility to achieve the broader environmental goals. This is a dynamic domain, one that always engenders new ideas and involves new roles on the part of various stakeholders. It is believed that new theories and procedures will grow to be the physical environments and situations changes. The role of planners and urban designers will therefore gather similarly significance within the field.

Climate simulations of this kind are critical to quantify the benefits of proposed urban design scenarios. The simulation output visualized in simulated ENVI-met 3.0 can act as a basis for the architectural design and urban planning decisions.

As a wide perspective, it can be concluded that the principle of urban design that affects microclimate and therefore human comfort is a vital one, and desires to be considered/addressed through a number of recommendations, guidelines and special measures. The subsequent is a focused set of recommendations based totally on the above-presented study:

- Rules ought to include percentages of open areas that accommodate adequate vegetation due to their great impact on the microclimate and human comfort.
- Further research could be conducted on different parameters along with shading factors or building orientation.
- Use albedo surface substances to reduce the mean radiant temperature.
- Promote simulation of reliable results prior to urban development.
- Human physiological comfort ought to merge with psychological needs which may be investigated by a simple questionnaire survey in future researches.

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